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What to Do on Your Summer Vacation

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Summer vacation brings back fond memories: playing frisbee in the park, bike-riding till dusk, sipping lemonade on the porch with Grandpa, collecting shells at the beach, solving that difficult math problem you've been working on for the past several weeks. Wait a minute, you say? Many mathematics majors don't realize that numerous summer opportunities exist (many of them *paid*, so you don't need to get that job bagging groceries, too). A math program provides intellectual stimulation during those hot summer months, bringing your level of concentration up from swatting flies and applying sunscreen. The following descriptions are from actual participants in a few of the many available programs. You might even know students at your own school who would love to share their experiences with you. Your professors and academic advisors also serve as invaluable resources, and the Internet has a wealth of information. Start looking now to plan your summer of 2001!

Internships

One type of summer fun you can have is in an internship, learning first-hand what a career using mathematics would be like. Actuarial science, one type of internship, appeals to many mathematicians due to the variety of tasks encountered in day-to-day work. Actuaries associate with accountants, bankers, computer programmers and statisticians, and can find opportunities for work in the insurance industry, government, financial world, and investment or consulting firms. For more information on an actuarial career, see the homepage for the Society of Actuaries, `www.soa.org`.

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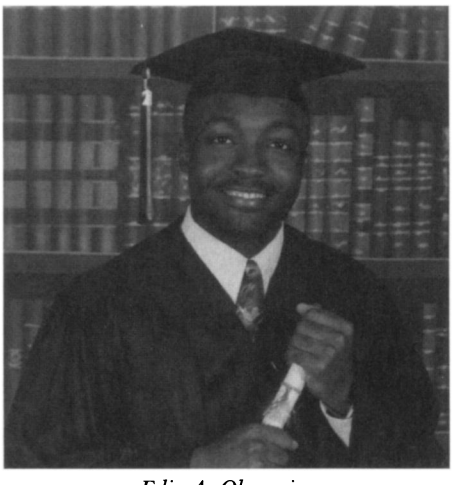
Hewitt Associates — Felix A. Okwaning

While considering math-related career options, I found actuarial consulting to be really interesting because of the analytical approach to problem solving in the financial world. An actuarial consultant is one who models and gives advice on financial security involving uncertain future events. The actuary models the future by analyzing the past and assessing the risk involved, and with these results enables individuals and businesses to make better decisions with a clearer view of the likely range of financial outcomes.

The first step I took toward becoming an actuary was to take the first of several exams towards my certification. This exam covered calculus and linear algebra. The exams for certification have been changed, combining the calculus and linear algebra with the probability and statistics exams from the old system to form a single exam for the new system. To become an "associate" of the Society of Actuaries, one must pass the first six exams, while "fellows" have passed two additional exams. The second step I took toward my career was to find an internship in one of the many actuarial consulting firms. I was fortunate to obtain an internship with Hewitt Associates.



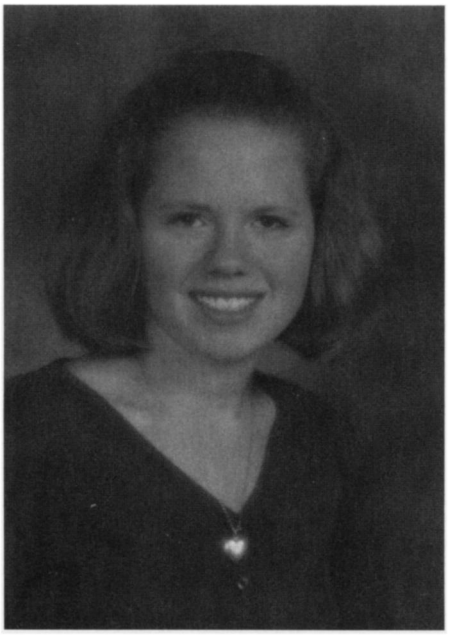
Felix A. Okwaning

Training is constantly provided for actuaries at Hewitt. Although I did not solely undertake any project since I was new on the job, my coaches and unit manager made sure I had a feel of everything actuaries do by working with different actuaries on different projects. I needed this information because I wanted to confirm that being an actuary was how I wanted to spend the next half of my life. I calculated benefits for employees of different companies. I also saw an evaluation report, a report put together by an actuary to confirm the liabilities and assets of the company. A report is also filed by an actuary with the government to confirm that a company has enough money and assets put away to meet future liabilities. Actuaries build and use mathematical models of the past to forecast the future, allowing their clients to make logical financial decisions. The most fun thing I did was when I did some one-on-one, on-site consulting with clients, assessing and advising on the calculation of benefits.

Actuaries apply the analytical skills they learned in math classes, and use this ability to transform many different situations using mathematical models. The work done by actuaries enables companies to make better financial decisions. It is a fun profession for those of you who like applied math and also like to interact with the outside world by doing some consulting.

Research Experiences for Undergraduates (REU)

These programs provide undergraduate students the opportunity to engage in creative exploration of recent work in a variety of mathematical fields. Mathematical requirements, length of program, and general focus vary by host institution. Generally REUs target students completing their second or third year and run from six to ten weeks. Frequently the results of a student's work leads to a publication in a scholarly journal. A complete list of NSF-sponsored REU programs can be found at: `http://www.nsf.gov/mps/dms/reulist.htm`.



Andrea Frazier

The University of Tennessee–Knoxville (UTK) — Andrea Frazier

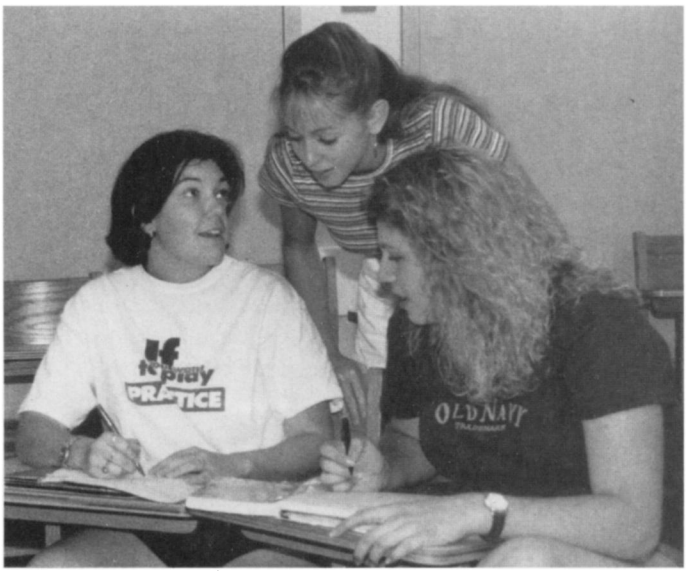
The Knot Theory lecture starts a few minutes after nine; the ten of us agree that this is more fun than the first lecture series (on partial differential equations), but a lot of people find it harder to get up and dressed in time for class as the summer rolls on. We don't have homework for these courses; they're organized so all the REU students have a chance to get to know one another. Of course, the program's housing consists of campus apartments, all on the same hallway, so we hang out together outside of the classes as well.

After class, some of the students go off to meetings with their advisors; most of us work individually with a professor from UTK, but the REU also gives students the chance to do research at the Oak Ridge Laboratories nearby. Since I've already met with Dr. Anderson (my project advisor) at eight, I go upstairs to the computer labs, where I check my email, type up new results using LaTeX, or prepare for my mid-program presentation.

After lunch, I'll dig through the library for an algebra book that Dr. Anderson has suggested and a graph theory text so I can look up a theorem that's been bothering me. I've nicknamed my project "The Trials and Triangulations of a Zero-Divisor Graph" because I was originally searching for triangles in graphs created by assigning the zero-divisors of a commutative ring to vertices on a simple graph. We eventually changed the way we were looking at an old article on the subject and discovered that we already knew which types of graphs contained triangles; now I'm trying to find formulas which count the number of triangles, which seems to require graph theory and combinatorics along with commutative ring theory. (I ended up finding ways to count complete graphs on n vertices in $\mathbf{Z}$ mod p^n graphs, and conjecturing a method for reduced rings.)

Specialty Programs

There are other summer opportunities that have a particular focus in terms of participant selection, program format, or integrated study combining mathematics with other disciplines. All try to show their participants the beauty and usefulness of mathematics. The Carleton/St. Olaf Summer Mathematics Program (`www.mathcs.carleton.edu/smp/`) is aimed at women finishing either their first or second year of college. The Summer Institute in Mathematics for Undergraduates (`http://cuhwww.upr.clu.edu/~simu`) is designed for Chicano/Latino and Native American students who have completed two years of school. The National Security Agency's Director's Summer Program (`http://www.nsa.gov/programs/employ/`) is a twelve-week program where students work cooperatively with



From left to right: Jenn Kenney, Heather Garten, and Jennifer Gliesman discuss mathematics at the 1998 SMP.

mathematicians on problems in the fields of abstract algebra, geometry, number theory, combinatorics, graph theory, probability, statistics, and analysis. The minimum mathematical requirements for participation include a full-year course in both analysis and abstract algebra. The Mathematical Association of America maintains an extensive list of summer opportunities which can be found at: `http://www.maa.org/students/reustuff/pages/smrpage.html`.

Summer Mathematics Program (SMP) — Heather Garten

During the summer of 1998, I attended the Carleton/St. Olaf Summer Mathematics Program for Women (SMP). I applied at the encouragement of my professor because I felt this would be an excellent opportunity for me to sample the realm of mathematics, and for me to see if math is truly what I desire to study for the rest of my life.

The caring attitude of the professors and directors of the SMP provided a good environment to work and learn in. Throughout the four-week program, we took two courses: algebraic coding theory and dynamical systems. Since we did not receive any grades, there was not real competition. The work was rigorous, but all the girls supported each other, working together to achieve a common goal: learn as much mathematics as possible in a month.

Classes took place in the morning, and in the afternoon we would attend informative panel discussions, ranging from how to get into graduate school to what problems women face in the field of mathematics. The one I remember the most was the panel of professionals in math-related careers who were very encouraging about mathematics, and enthusiastic about their work. Also, we would have guest lecturers who would speak about their research. Most of these topics were foreign to me, so I highly enjoyed learning about them.

On the weekends we took trips, went to dinners, and arranged fun activities to do. Some of the activities included hiking, tubing, and visiting sites of local interest.

Without a doubt in my mind, it was one of the best, most stimulating, and exciting experiences of my life. Due to the support and encouragement I received at the SMP, I knew I would attend graduate school and pursue a doctorate in mathematics.

Summer Institute in Mathematics for Undergraduates (SIMU) — Everilis Santana-Vega

In a typical day at SIMU 1999 I woke up at my *villa* (an apartment at the beach) in Palmas del Mar Resort in Humacao, Puerto Rico. I took a glance at the beach, and got ready to catch the van at 8:30 AM. The morning seminar was from 9:00 AM to 10:15 AM. There were two different seminars; mine was about Gröbner Bases, an exciting area of computational algebra that has many applications. At 10:15 we usually took a break and started the problem session. We worked the problems in groups of three, changing the composition of the groups every week, so we had the chance to work with all our classmates. As we worked through our problems, we were helped by the seminar assistants who were graduate students who knew a lot about Gröbner Bases.

At 1:15 we had our Laboratory sessions. Dr. Little, the seminar leader, assigned us a bunch of problems that we solved using *Maple* software. At 2:30 PM we got back to the problems from the morning sessions. Sometimes Dr. Little gave us a hint to solve the hardest problems, and seminar assistants would help us if we got stuck. The groups frequently figured out different ways to solve the assigned problems. At 5:00 PM we had dinner and then went back to our villas.

During the first three weeks, Mondays through Thursdays were the most work-intensive. On Fridays we had our morning seminar and the problem sessions, and after din-

From left: David Ortiz, Prof. John Little, Everilis Santana-Vega, and Thomas Castillo at SIMU 1999.

ner we had the colloquia. Each week we attended a talk given by mathematics professors or researchers. Through these colloquia we had the opportunity of meeting successful Latinos who encouraged us to set higher goals, especially attending graduate school. On Saturdays we took different trips, visiting places such as Old San Juan, Arecibo, El Yunque National Rainforest, while Sundays were free.

The last three weeks of the program we worked on a research problem in groups of three. After picking one of the research problems suggested by Dr. Little, we started with the "real" work. Depending on the problem we read various papers and reviewed past coursework, including linear algebra and vector calculus.

I remember the satisfaction when we got something right and the dynamic of the group. Sometimes we had to decide which path to take among the different ideas that we had. If one of them did not work, we would jump on to the other. We had a great time studying, discussing ideas about math, and learning new concepts and computational tools.

I had a wonderful experience at SIMU 1999. I learned a lot of new mathematics and computational tools. I had an excellent advisor, and seminar assistants. My classmates were smart students who loved mathematics, and became my friends. I enjoyed working with my team members in the project, and accomplishing many of our research goals. Now I am much more confident about what I am capable of doing, and my potential as a graduate student.

Director's Summer Program (DSP) — name undisclosed

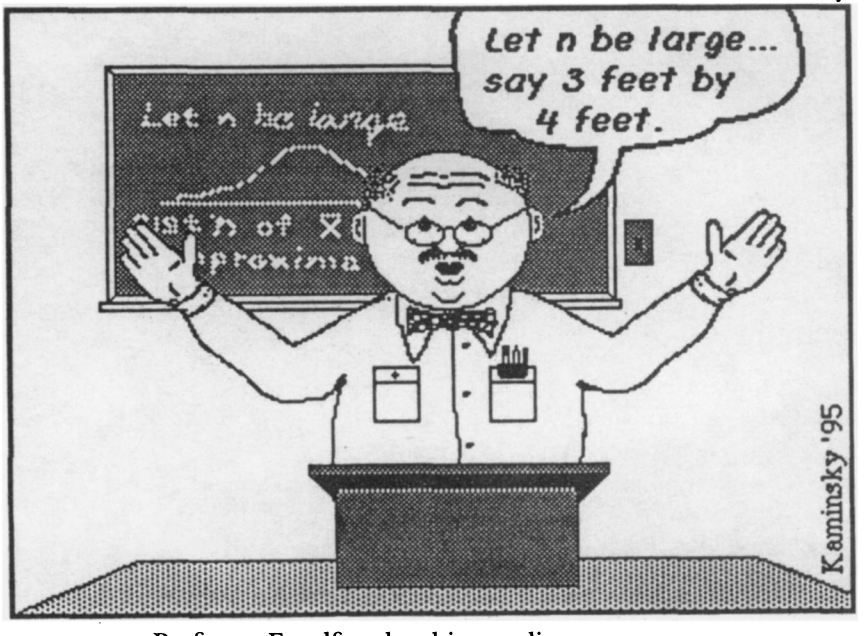
During the summer of 1999, I had the exciting opportunity to work for the National Security Agency (NSA) in their Director's Summer Program (DSP). I found out about the program via their website and applied in October of 1998. This October 15th deadline is much earlier than the January deadlines of REUs, because the NSA has to perform an extensive security check before it can employ anyone. Investigators interviewed my friends, looked at my credit history, reviewed the security paperwork I spent several days filling out (known affectionately as the "long form" by NSA employees), and even flew me to Washington, D.C. for a polygraph test. The directors of the program had decided to hire me in January, but it wasn't until around April that I finally received a security clearance.

Thirty other DSP students, a few college students employed in other NSA programs, and I arrived in Maryland at the beginning of June. The NSA had arranged furnished apartments for us, about ten minutes' drive from the Agency. After a few weeks' intensive training in classified mathematics, we broke into groups of three or four to begin solving problems. Unlike at most REUs, the research we did was applied to specific real-world problems the NSA was facing.

Working for the NSA had a few disadvantages. The classified nature of the work means there is no chance that your research will ever be published, and you can't discuss your work with anyone. Some people might also be uncomfortable working for a branch of the military. Moreover, I personally found the location of the work—suburban Maryland—rather bland and spiritually stifling. On the other hand, the work itself is exciting, and the atmosphere is very cooperative and friendly. It was also really fun to live with such a large, diverse group of math students for the summer. The cost of living is expensive—rent was $400/month per person, even with 6 roommates—but the salary more than covers it: if you cook for yourself, you can expect to make $4000 or $5000 profit over the summer. Another benefit is that if you want to return for another summer, the NSA will make every effort to find a place for you.

Most DSP students had just finished their junior year in college, but several had already graduated. All had extensive math backgrounds, but there was still quite a spread between the most brilliant and those (like me) who felt a little outclassed. All participants must be U.S. citizens. I strongly recommend the program to any math student seeking a summer research experience. ■

Cartoon Corner **Ken Kaminsky**



Professor Fogelfroe has his own litmus test to see whether or not his students are paying attention.